Assortment and Manufacturing Methods of Stump Socks

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Abstract

Today, there is a wide range of reasons for a limb amputation: traffic accidents, industrial and home injuries, congenital anomalies and malignant tumours, burns, diabetes, etc. During the war, it is gunshot wounds, as a result of which a limb amputation is the only decision to save the patient's life and prevent further development of the disease. In the period of martial law, the issue of preserving the health of military personnel is extremely relevant as one of the factors of increasing the combat capability of the troops. Prosthetic technologies allow amputees to continue their lifestyle and maintain social status despite the loss of a limb. However, between amputation and prosthetics, there is a rehabilitation process. Swelling is an urgent problem during this period. Compression therapy with an elastic bandage, which creates pressure on the stump is the method for its prevention. At the same time, the purpose of this therapy is to correct stump formation, to repair the scars, and to reduce phantom pain. That is why, compression covers are used after the treatment of an open wound. The quality of such a product depends on its conformity to the shape and size of a particular patient's limb and the distribution of pressure created by the product along the limb. Solving the issue of designing rehabilitation products for people with an amputated limb will contribute to the introduction of technologies aimed at the rehabilitation and recovery of the health of citizens of working age in the textile industry of Ukraine.

Keywords: stump socks, amputation, pressure, elastomeric thread.

1. Introduction

Limb amputation is used in the case of a direct threat to the patient's life and the ineffectiveness of conservative methods of treatment. Limb loss can be the result of trauma, malignancy, peripheral vascular disease, or a congenital anomaly. Amputation of the lower limb is more common than the upper limb. Lower extremity amputations account for approximately 85% of all amputation cases. Diabetic foot syndrome is the main cause of lower limb amputations in the world today. The scale of the incidence of diabetes in the world has acquired the characteristics of a pandemic. Prevalence in adults in 2017 was 8.8% of the world population, with the anticipation of a further increase to 9.9% by 2045. In total numbers, this reflects a population of 424.9 million people with diabetes worldwide in 2017, with an estimate of a 48% increase to 628.6 million people by 2045. On a global scale, diabetes hits particularly 'middle-aged' people between 40 and 59 years, which causes serious economic and social implications [1].

Since 2014 war in Ukraine has touched almost every family, and in 2022 is leading to an increase in the number of people with limb amputations regardless of the field of employment: militarists or medicines, volunteers, communal services, rescue, teachers, farmers, etc. It was established that the cause of traumatic limb amputation was 78.4% mine-explosive injuries, 11.7% - explosive wounds, and 5.9% - gunshot wounds. Almost 84.3% of military personnel lost one limb, 13.7% lost two, and 2% lost three. Amputation of the upper limb was performed in 9.8% of patients. During the full-scale war, according to the data of the Military Medical Clinical Center of the Western Region for the period of 2022 (February-September), 63.3% of wounded soldiers received combat damage to their limbs. Among them, 17.8% were injured by firearms, 10.4% by shrapnel and 68.1% by mine-explosive injuries. 5.8% of victims were treated for amputation stumps, and 4.3% of surgical interventions were performed according to primary indications [2]. In contrast to the non-traumatic type of amputations, the age of injured military servicemen varies from 18.9 years to 60 years, that is, the average age is 33.04±1.5 years. Amputation of the lower extremity (67.5%) prevailed over the upper extremity (32.5%) in combat surgical trauma. The frequency of amputation of different segments of the upper limb did not differ significantly: shoulder segment – 29.0%, elbow – 40.3%, hand – 30.6%. The frequency of amputation of the femoral (42.6%) and tibial (41.1%) segments of the lower limb is higher than that of the foot (16.3%). The frequency of upper and lower limb amputation differed only at the level of the hand (30.6%) and foot (16.3%) segments. Clinical and statistical data on amputation of limbs in victims should be taken into account when determining the need for prosthetics of the corresponding segments of the limbs [3].

Losing a limb always causes severe psychological trauma, making life, movement, and self-care difficult. Changing the appearance and shape of the body requires adaptation of the patient and his relatives. Any amputation is not only a severe physical injury, but also a strong and long-lasting psycho-emotional and social stress. Most patients are afraid of the unknown. They expect help in solving their social and household problems. In addition, young amputees are of working age, in education, and have responsibilities such as dependent children. Therefore, the impact of amputation in young amputees may be different than in older people. The use of a prosthesis, especially by young people, increases independence and allows them to perform everyday tasks, as the prosthesis allows them to walk, which improves their mobility and allows them to perform tasks independently. Amputees who cannot use prostheses are dependent on a wheelchair and need

additional devices or assistance to perform daily activities. The limited ability to walk negatively affects the quality of life of people with amputees. The level of amputation, age and other concomitant diseases limit the use of the prosthesis and the ability to walk. However, the most important factors are effective rehabilitation, psychological motivation and physical training, which can be improved over time [4]. Therefore, solutions to the issues of support, rehabilitation, and prosthetics allow people with an amputated limb to continue living, and to return to the highest possible level of functionality and independence, while maintaining professional abilities and social status. The work aims to present a summarized analysis of requirements for socks for amputated limbs, their assortment and manufacturing methods.

2. Results and discussion

Scientists from different countries of the world direct their efforts to solve the issue of creating functional therapeutic and preventive means for the rehabilitation of patients after amputation of a limb by improving the design, finding new types of raw materials and their manufacturing technology. General adaptation is directly related to the use of technologically modern prostheses, such as a microprocessor prosthesis or a prosthesis with an active vacuum system, as it provides the ability to perform daily activities, unlimited activity, physical functions, and mental health [4]. However, the question of prosthetics is preceded by the question of forming a stump: after the wounds have healed, it is necessary to treat the swelling of the limb and form a stump. The early postoperative period is an important stage and creates the basis for the success of all subsequent actions. As a rule, active rehabilitation measures at this stage begin 3-4 days after the operation, if the patient's condition is stable. It is important to maintain the mobility of the joints and the elasticity of the scar in case of contracture manifestations. Therefore, in agreement with the treating surgeon, lymphatic drainage massage, physical therapy and individual classes with an instructor are introduced as early as possible.

Swelling of the stump occurs almost always after amputation and is expressed in different patients to different degrees. The causes of the stink are physiological and include impaired blood flow. The main method of combating swelling is the application of compression therapy to the limb. Correct compression improves blood circulation, reduces pain, and can also speed up the process of adaptation to the prosthesis. The doctor’s instructions may include various options for compression therapy techniques: bandage stump, wearing special silicone liners, and special socks.

The simplest method for compression therapy is elastic bandages. However, the application of such a bandage requires special considerations and practical considerations; it is initially applied by a specialist, or the patient is required to undergo special instruction in bandage technology. It is very important to do it correctly because a loose bandage will not prevent or eliminate swelling, tight one can damage the tissues of the stump, injure, and disrupt blood circulation. Additionally, the pressure created on the stump should be gradient: the highest at the bottom of the limb with decreasing to the top. The use of a compression cover improves blood circulation, reduces pain and swelling, contributes to the treatment of phantom pain, and also allows to form the stump to the desired shape before wearing the prosthesis throughout life. The design of a knitted product of a certain shape must to fit the body shape, and in the case of prosthetics - to the level of amputation. In medical practice, 12 main levels of foot amputation are used, below the knee, disarticulation in the knee joint, above the knee, and disarticulation in the hip joint. There are the following levels of amputation for the upper limb: at different levels of the hand (partial hand); wrist disarticulation; at the level of the forearm (trans-radial); elbow disarticulation; trans-humeral; shoulder disarticulation; scapula-thoracic disarticulation. Accordingly, textile products should be of appropriate length and diameter.

Socks for stumps, as a product of certain shape, are primarily designed to protect the skin from external factors (prevention of friction, redness, temperature drop), absorption of sweat from the surface of the amputated limb, its thermoregulation due to a violation of the blood supply. The assortment of compression socks for stumps is determined by the level of amputation of the limb and the level of physical activity of the user. There are compression socks for the stump of the upper limb (hands), legs and thighs of the first and second compression classes. These socks are distinguished by length and diameter, which depend on the girth of the leg in the lower part of the limb. In the case of amputation of the lower limb at the level below the groin, the compression sleeve for the stump has an additional fastening system on the patient's belt. The fastening system can be a belt or bandage, which is connected to the stump. Accordingly, this fastening system can be used in case of amputation of the left or right limb or both at the same time [5, 6].

Most often, natural types of raw materials are used for the manufacture of stump socks: cotton and woollen yarn, depending on the season of operation. For all-season of stump socks, polyester and polyamide textured threads are used, which are hydrophobic types of raw materials and prevent the development of pathogenic microflora due to sweating. Compression socks for stumps are made with the introduction of elastomer thread into the structure of the knitted material. The yarn of a new generation with the effect of sweat removal, temperature regulation and antibacterial action is used for the production of functional compression socks. As a result of swelling, the amputated limb may lose or increase its volume in the transverse direction, manufacturers offer 1, 3 or 5-layer socks for the stump of daily use [6, 7]. This technological solution allows the user to ensure the correct fit of the stump in the socket of the prosthesis. Such socks ensure flawless integration of the stump with the prosthesis. The choice of raw materials for its manufacture ensures a drop in temperature by a degree or two, as well as the ability to remove moisture, providing comfort throughout the day. Manufacturers use small-diameter circular knitting equipment (circular stocking machine) to make stump socks. Compression socks for stumps are made on circular knitting equipment of small diameter with the possibility of adjusting the amount of tension of the elastomer thread, which

is introduced into the structure of the knitwear and provides the necessary level of compression of the textile product. There is also the practice of making stump socks on a flat knitting machine using sewing operations to ensure the shape.

The achieved effect of a compression product depends on the material characteristics and the created pressure level, as there has been compression and movement of soft tissues, a reduction of the covered site`s sizes. The main condition for compression product manufacturing is the use of elastomeric threads with high stretchability and elasticity. The physical and mechanical characteristics of the knitted material, the functionality of the product as well as the therapeutic and preventive compression effect depend on the knitting parameters and the fabric`s structure. In addition, the pressure created by the product depends on the degree of the fabric`s elongation on one or another body part and the curvature radius at a contact point of the surface. Thus, the required result of compression is a consequence of the correct choice of material, the pressure value on the body, and the correction effect.

The elastomer thread is the main element in the pressure-generating structure. It can be introduced into the structure in several ways, but the optimal option is the option that ensures its reliable fixing in the structure during exploitation, the uniformity of the loop structure, and extensibility and dimensional stability. Knitted fabric, in which elastomeric threads are fixed as a weft, has the largest share of recovered elongation in width and the minimum content of the elastomeric thread. Such knitwear has increased stretchability in one direction. Knitted fabric has the smallest part of elastic recovery along the width and the maximum content of elastomer thread when fastening the elastomer thread with loops. However, it has increased stretchability in both directions [8]. In a single knit, the elastomer thread can be fixed tucks, as a result, the elastomer thread has lines between the places of fixed. The appearance of the supporting surface of the knitwear depends on the repeat of the introduction of the elastomeric thread in the structure.

3. Conclusion

As a result of the analysis, statistics on the need for compression socks for stumps for upper and lower limbs were summarized. It was established that in the postoperative period, it is recommended to use compression socks for the stump, which ensures the restoration of blood supply. Small-diameter circular knitting equipment is used for the production of such socks, which allows you to adjust the feed of the elastomeric thread. Elastomer thread is inserted into the structure of the knitwear to create compression. Compression socks for stumps are made with 1 and 2 levels of compression. Cotton and woollen yarn, polyester, and polyamide textured threads are used as raw materials. In addition, functional yarn can be used to make socks for a stump, which provides perspiration removal and also an antibacterial effect and does not lose its properties during repeated washing. The design and dimensions of the stump socks depend on the part of the limb amputation. The authors plan to investigate the influence of the structure of the knitwear, the type of raw material, and the method of introducing the elastomer thread into the soil structure on the functional properties of the stump socks in order to improve their design and functional properties.

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